

REMARKS

After entry of the amendments cancelling Claims 18-20, Claims 1-4 will be pending. The Examiner has maintained a rejection of Claims 1 - 4 under 35 U.S.C. § 103(a) as being unpatentable over the combination of Dillon et al. (Surface Science 322(1995) 230-242) and Penneck et al. (U.S. Patent No. 4,985,313). Applicant thanks the Examiner for the opportunity to discuss this rejection in a telephone interview with Applicant's representative on February 23, 2008. The comments herein are consistent with what was discussed and emphasize how the cited references fail to teach or suggest deposition of more than one monolayer of Al_2O_3 in each deposition cycle as claimed and thus do not render the claims anticipated or obvious.

Applicant respectfully submits that the combination of Dillon and Penneck does not teach or suggest *inter alia* deposition of Al_2O_3 on a substrate by a cyclical sequential vapor deposition process in which the substrate is exposed to trimethyl aluminum (TMA) and atomic oxygen in a reaction chamber and wherein in each cycle more than one monolayer of Al_2O_3 is formed.

1. Neither Dillon nor Penneck disclose forming more than one monolayer per cycle

Claim 1 explicitly indicates that in each cycle, "more than one monolayer of Al_2O_3 is formed." In contrast, as discussed in the interview, Dillon teaches a true atomic layer deposition process in which no more than one monolayer is deposited per cycle. Dillon states that "[i]n the simplest form of atomic layer processing (ALP), the adsorption is self-regulating and *a full or partial monolayer of an element is deposited per operational cycle....*" (Page 230, column 1; emphasis added). The Examiner found Dillon at pages 239 et seq. to teach variation in the thickness per cycle of the aluminum oxide layer. However, the section of Dillon cited by the Examiner is directed towards the per-cycle efficiency of coverage of the deposited atomic layer of aluminum oxide and not towards its thickness. As such, Dillon teaches variation in the thickness of the layer only *up to* a full atomic monolayer; Dillon does not teach or suggest a thickness greater than one full atomic monolayer. There is simply no teaching or suggestion in Dillon (or Penneck) to deposit more than one monolayer of Al_2O_3 per cycle. Indeed, Dillon explicitly teaches that the adsorption mechanism upon which the deposition technique is based is *self-regulating* so that Dillon does not even recognize the possibility of depositing more than a monolayer per cycle.

In the interview, when Applicant's representative suggested that the statement in Dillon

that “0.33 ML of Al_2O_3 is deposited per AB reaction cycle under similar conditions” (Page 241) teaches less than a monolayer, the Examiner expressed concern that “ML” may not refer to monolayer and asked Applicant to address this point. The unit “ML” must refer to a monolayer; other units do not make sense in the context. Deposition is a one-dimensional process of building layers upward. Therefore, rates of deposition are best measured in units of layers deposited per time. Applicant suggests that monolayers/cycle is the only such unit that would be abbreviated “ML” per cycle. The unit cannot be milliliters, since milliliters is a measure of volume, and using such a measure would render Dillon’s characterization of the Higashi *et al.* reports fatally vague, since a 0.33 milliliter/cycle deposition rate would depend on the area of the substrate. It is not reasonable to assume that Dillon would report results in such an ambiguous way.

Moreover, other publications and patents use the term “ML” as an abbreviation for monolayer in related contexts. See, for example, Dean *et al.*, U.S. Pat. No. 5,408,107 (Issued Apr. 18, 1995; col. 2, line 47 and col. 5, line 18) (“The heterostructure barrier 14 shown in FIG. 1 one consists of an approximately (~)18 monolayer (ML) lightly doped n-type $\sim(10^{15} \text{ cm}^{-3})$ GaAs....” and “The equations are solved on a uniform spatial mesh with a mesh spacing of approximately one (1) monolayer (ML).”) See also, for example, U.S. Pub. No. 2007/0148350 at ¶0040 and 2007/0265159 at ¶0065.

Therefore, for the reasons discussed above, Dillon does not teach, suggest, or enable deposition rates of greater than one monolayer per cycle. Moreover, achieving deposition of greater than one monolayer per cycle in the process of Dillon is not a matter of routine experiment. Certainly, if attaining higher deposition rates were a matter of routine experiment, Dillon would have done so rather than report a low deposition rate, especially given the temperature experimentation Dillon *did* do. (See page 238.) Moreover, Dillon is concerned with a precise, self-limiting deposition process. Adjusting the deposition rate to greater than one monolayer per cycle would frustrate Dillon’s purpose. One of reasonable skill in the art would not have a reason to vary the process of Dillon above one monolayer cycle and there is no teaching or suggestion in the cited references of how such a deposition rate could even be achieved.

2. There is no reason to combine Penneck with Dillon

The process disclosed in Dillon for the deposition of aluminum oxide does not teach or suggest using atomic oxygen as the oxygen source, as recited in Claim 1. Instead, every embodiment mentioned in Dillon relies on water vapor to grow Al_2O_3 . There is no reason in Dillon to use a different oxygen source, much less to use highly reactive atomic oxygen.

The Examiner found that while Dillon does not teach use of atomic oxygen as the oxygen source, this deficiency was made up for by Penneck. The process disclosed in Dillon comprises a plurality of cycles in which Al_2O_3 is deposited. That is, thin layers of Al_2O_3 are deposited in multiple cycles. In the process in Penneck, all of the aluminum is deposited first, after which the layer is oxidized. There is no indication in the art that Penneck's use of atomic oxygen could or should be carried out cyclically. Nor is there any indication in the art that Penneck's use of atomic oxygen would be desirable or useful in the process of Dillon, where only monolayers of aluminum precursor are to be oxidized rather than the considerably thicker aluminum layer being oxidized by Penneck.

Penneck is also directed to forming aluminum oxide on cables, and thus would not have the same concerns as Dillon, which is directed to atomically thin films for applications such as "high dielectric insulators" on silicon surfaces. Because of the significant difference in the processes and results described in the references, one of skill in the art would not combine the teachings of Penneck with Dillon in a manner that meets the claims without a reason for doing so. Neither of the asserted references provide any such reason. There is simply no reason in the references or the art generally to use atomic oxygen in Dillon's cyclical process nor any teaching of how to do so.

The difference in context between Dillon and Penneck is sufficiently great that one of reasonable skill in the art would not be inclined to combine the two, nor would one of such skill have a reasonable likelihood of success in doing so. A desire to reduce contamination cannot serve as the reason to combine because Penneck is concerned with reducing contamination from the use of electrolytic solutions, such as sulfates (*see* col. 8, lines 7-15). Such solutions are not used in the process of Dillon, therefore reducing contamination from them cannot be a reason for combination. Further, Penneck's mechanism for reducing contamination, namely plasma oxidation, has characteristics that would disincline a skilled artisan from using it in an ALD process and that would require undue experimentation and have unpredictable results.

In particular, the Dillon ALD process depends on precise reactions taking place on the deposition surface. Dillon is concerned with accurate deposition in the context of integrated circuits and thus in preserving the electrical characteristics of underlying layers. On the other hand, Penneck's oxygen plasma coating process is a gross, unconstrained process that is not concerned with precise, monolayer by monolayer deposition. Oxygen plasma is a highly reactive species that, in the context of Penneck, oxidizes multiple layers at once. One of skill in the art would understand that using plasma oxidation, as disclosed in Penneck, in the process of Dillon could oxidize underlying layers, especially early in the deposition process. Thus, a skilled artisan would not be tempted to combine the oxidation process of Penneck with an ALD process, even if reduction of contamination were a goal. The references do not disclose or suggest mechanisms for addressing such concerns. Moreover, in general, substitution of one element known to be useful for a given purpose (such as contamination minimization) in a CVD process would not lead to predictable results in an ALD process, especially in such divergent contexts.

3. Conclusion

Applicant respectfully traverses each of Examiner's arguments against allowability of the claims. The remaining dependent claims also teach further distinguishing features of particular utility, but are not separately addressed in view of the patentability of Claim 1, as discussed above.

In view of the remarks presented herein, Applicant respectfully submits that the pending claims are not obvious in view of the combination of Dillon and Penneck and request withdrawal of the rejections under 35 U.S.C. § 103(a) and allowance of the pending claims.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

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